GE Healthcare

TruSat™ Pulse Oximeter

Technical Reference Manual

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Technical Reference Manual

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Important

Rx Only (USA)

Attention! Consult the accompanying instructions, including all safety precautions, before using or servicing this device.

Responsibility of the manufacturer

The safety, reliability, and performance of this device can be assured by the manufacturer only under the following conditions:

- Assembly, extensions, readjustments, modifications, and repairs are carried out by authorized personnel.
- The electrical installation complies with relevant standards and regulations.
- The device is used in accordance with the *TruSat User's Guide* and is serviced and maintained in accordance with this manual.

Service and repair

Service and repair procedures must be performed by authorized service personnel. Repair this device or its parts only in accordance with instructions provided by the manufacturer. To order replacement parts or for assistance, contact an authorized service office. When shipping the monitor for repair, clean the monitor, allow it to dry completely, and pack it for shipment in the original shipping container, if possible.

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1. PRODUCT DESCRIPTION AND SPECIFICATIONS

This manual provides instructions for servicing the TruSat™ pulse oximeter.

This chapter contains:

- A general description of the monitor.
- Illustrations of the monitor.
- Safety precautions.
- Specifications.
- Details regarding compliance with standards for Medical Electrical Equipment.

1.1 General description

The TruSat pulse oximeter is a durable and portable monitor that measures oxygen saturation, pulse rate, and PI_r®, a relative perfusion index. The monitor is powered by an internal battery, which is charged through an external power supply.

Important: When using the monitor for the first time or after removing it from extended storage, charge the battery for three hours BEFORE you power ON.

The monitor contains an easy-to-read liquid crystal display (LCD) with a backlight for low-light conditions. The monitor also contains on-screen controls for changing monitor settings, a lock function, and an alarm system that generates audible and visual alarm signals.

The optional Trend Download board allows users to set the monitor clock, print, and download trends to a computer. Monitors can be factory-configured with this option. An upgrade kit is also available.

Important: Only OxyTip®+ sensors can be used with this monitor.

Related information

For a detailed description of the functions and general operating guidelines of the monitor, refer to the *TruSat User's Guide*.

For information related to sensors (sensor application and cleaning, for example), refer to the instructions for the sensor.

Technical competence

CAUTION: Only qualified service personnel should perform the procedures described in this manual.

Only authorized service personnel or competent individuals who are experienced with servicing medical devices of this nature should perform the procedures described in this manual.

1.2 Monitor features

Screen display, controls, and indicators

NOTE: The monitor is shown without the handle.

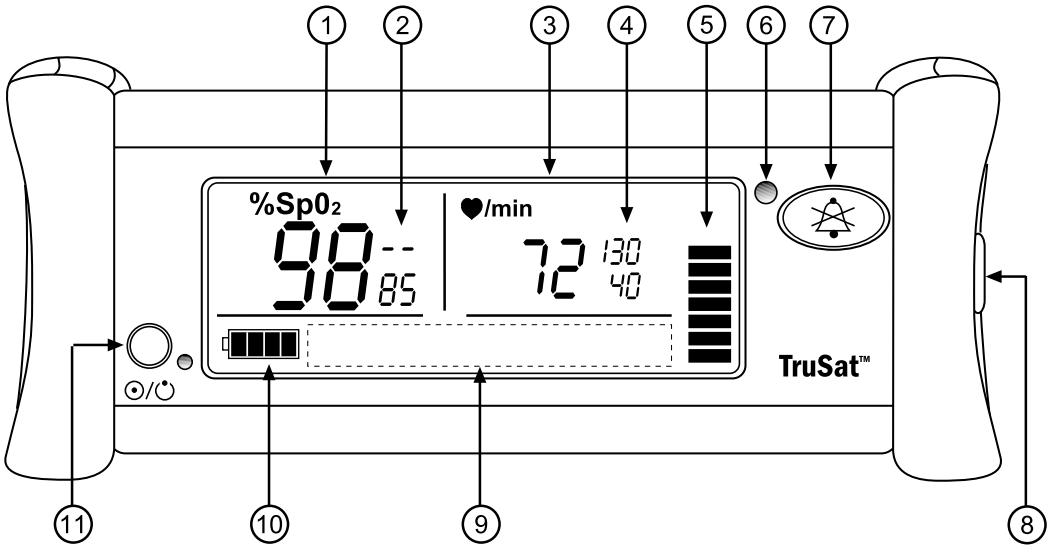


Figure 1-1. Monitor features

1 Oxygen saturation (SpO_2) measurement value

2 SpO_2 high and low alarm limit settings, adjustable

3 Pulse rate measurement value

4 Pulse rate high and low alarm limit settings, adjustable

5 Plethysmographic pulse bar (pleth bar)

6 Alarm LED

7 Alarm Silence button

8 ComWheel navigation and selection knob for changing monitor settings

9 Display area for on-screen control symbols (set pulse beep volume, set alarm volume, switch backlight ON/OFF, display PIr, print) and the lock symbol

10 Battery indicator

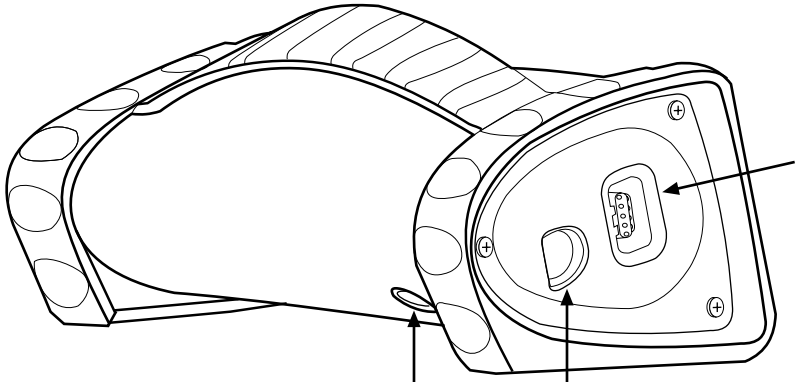
11 Power button and external power LED

Refer to the *TruSat User's Guide* for detailed descriptions of all controls and indicators.

Connectors

WARNING: When you connect equipment to the monitor, you are configuring a medical system and are responsible for ensuring that the system complies with IEC 60601–1–1 and with local requirements. Connect only external devices specified for use with the monitor.

WARNING: Use only sensors and cables authorized for use with this monitor. Failure to do so may cause interference with the measurement or result in increased emissions, decreased immunity, or damage to the equipment or system.



Sensor connector
Connect an OxyTip+ sensor or cable only.

Trend Download connector (RS-232)
Connect the TruSat/PC RS-232 cable or the TruSat/serial printer cable.

Power connector
Plug the power supply cable into this connector. Then, plug the power cord into the power supply and into the AC power outlet.

Figure 1-2. Monitor connectors

Information label and symbols

A label on the underside of the monitor contains the model number, serial number, date of manufacture, and other information about the monitor. The following symbols also appear on this label and/or on the packaging for the monitor:

Sensor connector; defibrillation-proof type BF applied part

DC current

RS-232

RS-232 connector for the Trend Download option

Manufacturer

Power supply connector; external power in

Other symbols on the monitor or the screen are described in the *TruSat User's Guide*.

1.3 Safety precautions

Precautions associated with following safe practices while using the monitor appear throughout this manual. General precautions are listed below. Carefully read all precautions in this manual before repairing or using the monitor.

NOTE: For complete information about the safe and appropriate use of a sensor, consult the instructions for that sensor.

Warnings

WARNINGS indicate potentially harmful situations that may cause injury to a patient or operator.

- Do not use the monitor if the startup tones do not sound, the validity of data is questionable, or if the monitor fails to function as described. Refer to the appropriate sections of this manual to identify and correct the malfunction.
- Do not use the monitor in the presence of any flammable anesthetic mixture.
- Use only hospital-grade, grounded power outlets.
- Use only sensors and cables specified for use with this monitor. Failure to do so may cause interference with the measurement or result in increased emissions, decreased immunity, or damage to the equipment or system.
- This monitor is not intended for use in a magnetic resonance imaging (MRI) environment.
- When you connect equipment to the monitor, you are configuring a medical system and are responsible for ensuring that the system complies with IEC 60601–1–1 and with local requirements. Connect only external devices specified for use with this monitor.
- Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

Cautions

CAUTIONS indicate conditions that may lead to equipment damage or malfunction.

- Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.
- Do not store or use the monitor outside the temperature and humidity ranges stated in the *Specifications* section of this manual.
- Never use a battery if its insulative wrap is ripped, torn, or has other visible damage. A damaged battery wrap can cause internal shorting, overheating, or other equipment damage.

Disposal

Recycle or dispose of this medical device, its components, and its packing materials in accordance with local environmental and waste disposal regulations.

1.4 Specifications

Specifications are nominal and are subject to change without notice.

Factory settings

Setting	Range	Factory setting
High SpO_2 alarm limit	51 to 100% or OFF (— —)	OFF
Low SpO_2 alarm limit	50 to 99% or OFF (— —)	85
High pulse rate alarm limit	30 to 235 bpm or OFF (— — —)	130
Low pulse rate alarm limit	30 to 235 bpm or OFF (— — —)	40
Backlight	ON or OFF	ON
Pulse beep volume	0 (OFF), 1, 2, 3, or 4 *	2
Alarm volume	1 (low), 2, 3, or 4 *	2
Line power filter	50 Hz or 60 Hz	60 Hz

* For more information, see *Audio* later in this section.

Measurement

General

Pulse oximetry sensors: OxyTip+ sensors only

Method: red and infrared light absorption
Red LED wavelength range: 650 to 670 nm
Infrared (IR) LED wavelength range: 930 to 950 nm
Average power: ≤ 1 mW

SpO_2

Calibrated for functional oxygen saturation

Calibration range: 70 to 100%

Measurement and display range: 1 to 100%

Display resolution: 1%

First reading, full accuracy: ≤ 10 seconds

Accuracy, A_{rms}
(root mean square of paired values; previously represented by ± 1 SD):
70 to 100% ± 2 digits (without motion)
70 to 100% ± 3 digits (during clinical motion)[1]
70 to 100% ± 2 digits (during clinical low perfusion)
Below 70% unspecified

SpO_2 measurement accuracy is based on deep hypoxia studies using OxyTip+ sensors on volunteer subjects. Arterial blood samples were analyzed simultaneously on multiple CO-oximeters.

NOTE: Accuracy may vary for some sensors; always check the instructions for the sensor.

[1] Applicability: OxyTip+ Adult/Pediatric and AllFit sensors.

Pulse rate

Measurement and display range: 30 to 250 beats per minute (bpm)

Display resolution: 1 bpm

First reading, full accuracy: ≤ 15 seconds

Accuracy
30 to 250 bpm: ± 2 digits or ± 2%, whichever is greater (without motion)
30 to 250 bpm: ± 5 digits (during motion)
30 to 250 bpm: ± 3 digits (during low perfusion)

PI_r pulsatile value

Measurement and display range: 0.01 to 9.99

Display resolution: 0.01 PI_r

Monitor

General

Lock function: locks/unlocks alarm limits and other settings

Factory calibrated; power-on self-test with calibration check

Recovery time after exposure to defibrillation voltage: ≤ 30 seconds

Display

Liquid crystal display (LCD)

Backlight LED: ON or OFF

Plethysmographic pulse bar (pleth bar): ten-segment column; pulsates to indicate pulse rate and signal strength

Display update time
SpO_2, pulse rate, and PI_r values: 1 second ± 0.25 second
Plethysmographic pulse bar: 20 Hz minimum (.05 second)

Alarms

Visual and audible indicators for physiological alarms (SpO_2 and pulse rate limit alarms) and technical alarms (sensor condition, battery condition, internal malfunction)

Visual alarm indicator, red/yellow LED
High priority alarm: red ON or red flashing ON/OFF
Medium priority alarm: yellow flashing ON/OFF

Visibility (operator positioned in front of monitor: 4 m (13 ft.) at 30° angle in any direction

NOTE: When an SpO_2 or pulse rate alarm limit is violated, the related measurement flashes ON/OFF.

Audible alarm indicator: pattern varies according to alarm type and priority

Alarm Silence button: silences alarms for 2 minutes (press once; screen symbol is displayed) or indefinitely (press 3 times; screen symbol flashes ON/OFF)

NOTE: If an alarm condition is not present, the alarm LED is lit yellow to indicate future alarms will be silenced.

Audio

Pulse rate beep: tone rises as oxygen saturation increases and falls as it decreases

Adjustable alarm volume and pulse beep volume: 4-segment on-screen controls

Volume intensity at distance of 1 m (3.28 ft.): 45 dB minimum to 85 dB maximum

External power

Power supply (AC to DC converter)
AC power input: 100–240 V, 0.5 A, 50–60 Hz

Power supply (DC to DC)
DC power input from vehicle cigarette lighter: 12 V

Power supply output to monitor: 12 VDC, 1.25 A, 15 watt

Power indicator (green LED): ON while monitor is connected to external power

Line power filter (monitor setting): 50 Hz or 60 Hz

Internal battery power

Type: Internal, rechargeable, nickel metal hydride (NiMH), 3 AH, 12 VDC, 150 mA

Self-discharge when stored at room temperature (typical for all NiMH batteries):
at least 30% of a full charge remains after 3 months of storage

Capacity, fully charged, operating at room temperature:
Without Trend Download option: 35 hours
With Trend Download option: 24 hours
NOTE: Continuous use of the backlight reduces the time approximately 50%.

Charging time (full capacity): 3.5 hours typical

Battery indicator: 4-segment symbol; shaded segments represent battery charge
(0 shaded = low or depleted; 4 shaded = fully charged)

Automatic power OFF to conserve battery: 20 minutes after monitoring stops

Trend Download option

Trend data storage: 48 hours with a data storage resolution of 1 data point every 4 seconds

RS-232 serial port: DIN 6 circular connector
19.2K baud, 8 data bits, 1 start bit, 1 stop bit
Handshaking (RTS, CTS), full duplex, no parity

Environmental conditions

NOTE: To maximize battery life, store the monitor at room temperature.

	Operating	**Transport and Storage**
Temperature	10 to 40 ºC (50 to 104 ºF)	–40 to 70 ºC (–40 to 158 ºF)
Relative humidity, noncondensing	20 to 95%	5 to 95%
Atmospheric pressure	1060 to 697 hPa	1060 to 188 hPa
Approximate elevation	–378 to 3048 m (–1240 to 10,000 ft.)	–378 m to 12.2 km (–1240 to 40,000 ft.)

Dimensions and weight

Width/Depth/Height including handle = 21.8 x 11.5 x 10.3 cm (8.5 x 4.5 x 4 inches)

Weight = 1.25 kg (2.76 pounds)
1.47 kg (3.26 pounds) with Trend Download option

1.5 Compliance

European Union Medical Device Directive 93/42/EEC: Class IIb

EN 60601-1 *Medical electrical equipment – Part 1: General requirements for safety* (including Amendments 1 and 2)

- Type of protection against electric shock: Class I equipment/Internal electrical power source
- Degree of protection against electric shock: Defibrillation-proof type BF applied part
- Degree of protection against ingress of water (**EN 60529**): IPX2
- Not suitable for use in the presence of flammable anesthetic mixtures
- Mode of operation: Continuous

EN 60601-1-2 (2nd Edition) *Electromagnetic compatibility – Requirements and tests* For details, see *Electromagnetic compatibility (EMC)* later in this section.

CISPR 11/EN 55011 (Protection against emissions): Group I, Class B

IEC 60601-1-8 *Alarm systems – General requirements, tests and guidance for alarm systems in medical electrical equipment and systems*

LR 87853 C SP US

Medical electrical equipment classified in the US and Canada with respect to electric shock, fire, and mechanical hazards only, in accordance with the Canadian Standards Association CAN/CSA C22.2 No. 601.1 and Underwriters Laboratories Inc. UL 2601–1.

Related standards and tests

Standard	Description
EN 60601-1, clause 21	Rigidity, strength, handle loading drop test
EN 60601-1, clause 42	Temperature
EN 60601-1, clause 48	Non-toxic materials used for surface of case
EN 60601-1, sub-clause 59.2(b)	Resistance of case to heat and fire
EN 865, clause 44	Overflow, spillage, ingress of liquids, cleaning and disinfection
IEC 61000-3-2	Harmonic emissions
IEC 61000-3-3	Voltage fluctuations and flicker emissions
IEC 61000-4-2, level 3	Electrostatic discharge immunity
IEC 61000-4-3, level 2	Radiated RF electromagnetic field immunity
IEC 61000-4-4, level 3	Electrical fast transient and burst immunity
IEC 61000-4-5, level 3	Surge immunity
IEC 61000-4-6	Susceptibility to conducted EMI
IEC 61000-4-8	Power frequency magnetic fields
IEC 61000-4-11, Table 7	Operation during line voltage variations
IEC 60068-2-32	Operation during physical shock/drop and repetitive drop
UL 2601-1, clause 55	Impact test

Electromagnetic compatibility (EMC)

When using this monitor, take precautions to ensure electromagnetic compatibility.

Indications that the monitor is experiencing electromagnetic interference include, for example, a dashed display or sudden changes in the pleth bar height that do not correlate to the physiological condition of the patient. This interference may be intermittent and careful correlation between the effect and its possible source is important. Indications of interference should not occur if the monitor is used within its intended electromagnetic environment.

Electromagnetic interference, including interference from portable and mobile radio frequency (RF) communications equipment, can affect this monitor. When using the monitor, take precautions to ensure electromagnetic compatibility.

Recommended Separation Distances between Portable and Mobile RF Communications Equipment and the TruSat

The TruSat pulse oximeter is intended for use in an electromagnetic environment in which RF disturbances are controlled. The customer or the user of the monitor can prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the monitor as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of the transmitter **W**	**Separation distance according to the frequency of the transmitter** **m**		
	150 kHz to 80 MHz $d = 0.70\sqrt{P}$	**80 MHz to 800 MHz** $d = 0.70\sqrt{P}$	**800 MHz to 2,5 GHz** $d = 0.70\sqrt{P}$
0.01	0.07	0.07	0.07
0.1	0.22	0.22	0.22
1	0.70	0.70	0.70
10	2.2	2.2	2.2
100	7.0	7.0	7.0

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1: At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

Guidance and manufacturer's declaration - electromagnetic emissions

The TruSat pulse oximeter is suitable for use in the electromagnetic environment specified below. The customer or the user of the monitor should assure that it is used in such an environment.

Emissions test	**Compliance**	**Electromagnetic environment - guidance**
RF emissions CISPR 11	Group 1	The TruSat uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The TruSat is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Complies	

Guidance and manufacturer's declaration - electromagnetic immunity			
The TruSat pulse oximeter is intended for use in the electromagnetic environment specified below. The customer or the user of the monitor should assure that it is used in such an environment.			
Immunity test	**EN 60601-1-2 test level**	**Compliance level**	**Electromagnetic environment - guidance**
Electrostatic discharge (ESD) IEC 61000-4-2	± 6 kV contact ± 8 kV air	± 6 kV contact ± 8 kV air	Floors should be wood, concrete, or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	± 2 kV for power supply lines ± 1 kV for input/output lines	± 2 kV for power supply lines ± 1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment
Surge IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV differential mode ± 2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	< 5 % U_T (> 95 % dip in U_T) for 0,5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles < 5 % U_T (> 95 % dip in U_T) for 5 sec.	< 5 % U_T (> 95 % dip in U_T) for 0,5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles < 5 % U_T (> 95 % dip in U_T) for 5 sec.	Mains power quality should be that of a typical commercial or hospital environment. If the user requires continued operation during power mains interruptions, it is recommended that the TruSat be powered from an uninterruptible power supply or a battery.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	10 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
NOTE: U_T is the AC mains voltage prior to application of the test level.			

Guidance and manufacturer's declaration - electromagnetic immunity

The TruSat pulse oximeter is intended for use in the electromagnetic environment specified below. The customer or the user of the monitor should assure that it is used in such an environment.

Electromagnetic environment - guidance

Portable and mobile RF communications equipment should be used no closer to any part of the monitor, including cables, than the recommended separation distance calculated from the equation applicable for the frequency of the transmitter.

NOTE: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

Immunity test	EN 60601 test level	Compliance level	Recommended Separation Distance
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	5 V	$d = 0.70 \sqrt{P}$
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2.5 GHz	5 V/m 10 V/m	$d = 0.70 \sqrt{P}$ 80 MHz to 800 MHz $d = 0.70 \sqrt{P}$ 800 MHz to 2.5 GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m). NOTE: At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

Interference may occur in the vicinity of equipment marked with this symbol.

Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b]

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast, and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the TruSat is used exceeds the applicable RF compliance level above, the TruSat should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the TruSat.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 5 V/m.

2. THEORY OF OPERATIONS

This chapter contains:

- Functional block diagram.
- SpO_2, pulse rate, and PI_r measurement principles.
- Functional descriptions of the power supply, System board, Display board, and the Trend Download board (RS-232).

2.1 Functional block diagram

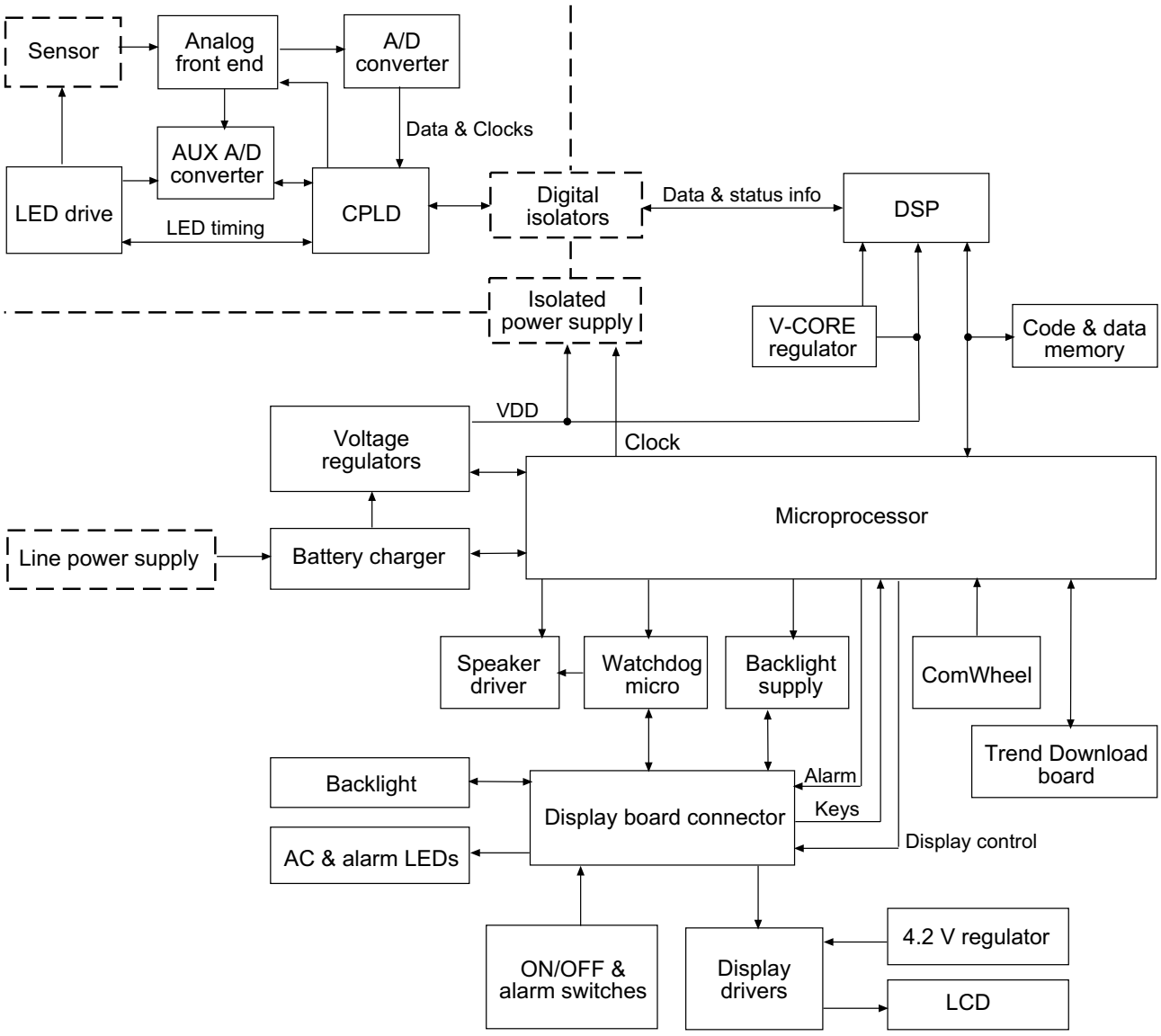


Figure 2-1. Functional block diagram

2.2 Measurement principles

TruSignal™ Enhanced SpO_2

TruSignal Enhanced SpO_2 offers improved performance, especially during challenging conditions of clinical motion and low perfusion. With ultra-low-noise technology, TruSignal selects the appropriate clinically-developed algorithm to compensate for weak or motion-induced signals and generate reliable saturation readings.

PI_r pulsatile value

The perfusion index measurement—the PI_r pulsatile value—is a quick and easy-to-use clinical tool that provides a dynamic numeric reflection of perfusion at the sensor site. PI_r is a relative value that varies from patient to patient.

The PI_r pulsatile value indicates the strength of the pulse signal at the sensor site—the higher the PI_r value, the stronger the pulse signal. A strong pulse signal increases the validity of SpO_2 and pulse rate data. Clinicians can use the PI_r value to compare the strength of the pulse signal at different sites on a patient in order to locate the best site for the sensor—the site with the strongest pulse signal.

Signal processing

This pulse oximeter uses a two-wavelength pulsatile system—red and infrared light—to distinguish between oxyhemoglobin (O_2Hb) and reduced hemoglobin (HHb). The light is emitted from the oximeter sensor, which contains a light source and a photodetector.

- The light source consists of red and infrared light-emitting diodes (LEDs).
- The photodetector is an electronic device that produces an electrical current proportional to incident light intensity.

The two light wavelengths generated by the LEDs are transmitted through the tissue at the sensor site and are modulated by arterial blood pulsation. The photodetector in the sensor converts the light intensity information into an electronic signal that is processed by the monitor.

The TruSat pulse oximeter uses the functional calibration method.

2.3 Power supply and battery

A Globetek power supply converts power from an AC power source (100 to 240 V, 0.5 A, 50-60 Hz) and outputs power to the monitor (+12 VDC, 1.25 A, 15 watts). It also provides the necessary isolation between the patient and the AC power supply.

An optional 12 VDC to 12 VDC power supply is available. It can be connected to an auxiliary power source, such as a vehicle cigarette lighter.

When the monitor is not connected to an external power supply, it is powered by an internal rechargeable NiMH battery (3 AH, 12 VDC, 150 mA). The battery connects to the System board.

2.4 System board

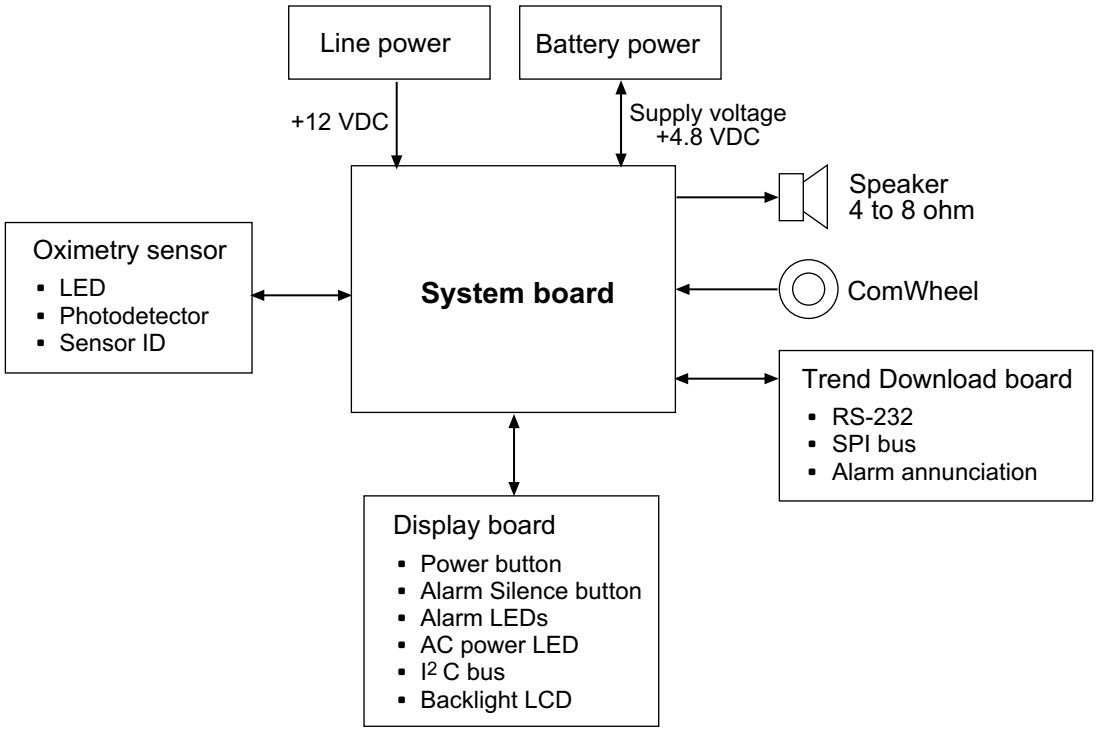


Figure 2-2. System board block diagram

The System board provides patient isolation, voltage regulation, over-current protection, watchdog features, and other functions related to system monitoring and control. An ID circuit on the board can output an analog voltage indicating the hardware version of the board. The System board also communicates printer functions to an installed Trend Download board.

The System board conditions power from the power supply and the battery. When a DC voltage is supplied from the power supply, the board charges the battery at a constant current while simultaneously supplying power to the rest of the circuit.

The board transmits data for the display and monitors the Alarm Silence and power switches. It controls the backlight and drives the speaker.

The System board drives the sensor LEDs and receives photodetector signals from the sensor. The output from the signals is used to determine patient oxygen saturation, perfusion, and pulse rate. The electrically-isolated side of the board contains the oximetry analog hardware, CPLD, and A/D converters. A +3 VDC rail input to a step-up isolation transformer provides +5.3 VDC isolated voltage to the oximeter side of the board. Digital Signal Processing (DSP), which processes the oximetry data, requires a core voltage of +1.5 V and an I/O voltage of +3.3 V.

An EEPROM contains the DSP boot code; a FLASH device contains the application code. The DSP is the master of the memory devices during the boot sequence; the microcontroller is master of the FLASH during normal operation.

The System board contains a connector for reprogramming the FLASH and for installing software upgrades, including boot, DSP, and system software.

Microcontroller

The System board microcontroller is responsible for system monitoring, user interface processing, speaker control, display control, alarm LED control, RS-232 communications, SPI bus control, enabling oximetry hardware, and real-time clock control.

The microcontroller is supplied by a +3 VDC signal, V_ON, which is always on when power is applied to the board. V_ON and VDD are created from the battery by a regulator. VDD is switched ON/OFF by the microcontroller.

An internal power supply monitor in the microcontroller resets the hardware if a brown-out condition is detected. A watchdog micro clears the display and causes a continuous tone to sound if no activity is detected.

2.5 Display board

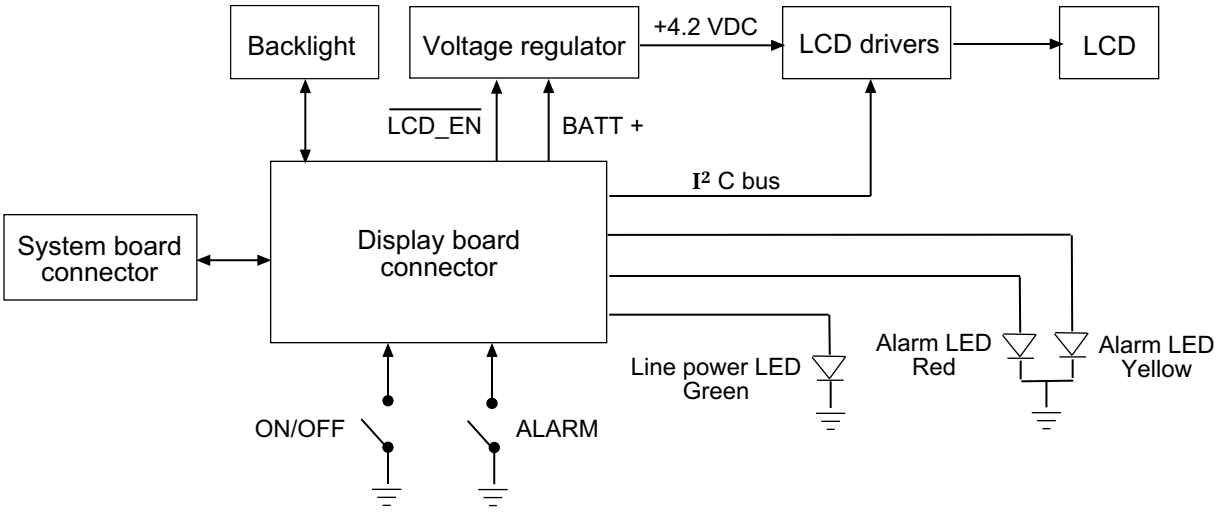


Figure 2-3. Display board block diagram

The Display board contains the liquid crystal display (LCD) on which information sent by the System board appears: oxygen saturation, pulse rate, PI_r, plethysmographic pulse bar (pleth bar), alarm limit settings, and screen symbols for changing monitor settings. It also displays indicators for the battery, alarm silence, lock status,. and alarm messages. The backlight, power switch, alarm silence switch, line power LED, and red/yellow alarm LED are located on the Display board.

The Display board connects directly to the System board through a 30-pin board-to-board connector. A BATT+ supplies power to the 4.2 V display regulator, which optimizes the LCD contrast. Two LCD drivers can drive up to 160 segments on the 4.2 V LCD, which contains 80 segment pins and 2 backplane pins.

The backlight can be switched ON or OFF by the user. It consists of 54 sets of 2 amber LEDs.

The green AC power LED monitors the DC line voltage from the external power supply. A microcontroller monitors the ON/OFF and ALARM switches on the board and drives the red/yellow alarm LED.

The Display board is shielded from the effects of EMC.

2.6 Trend Download board (RS-232)

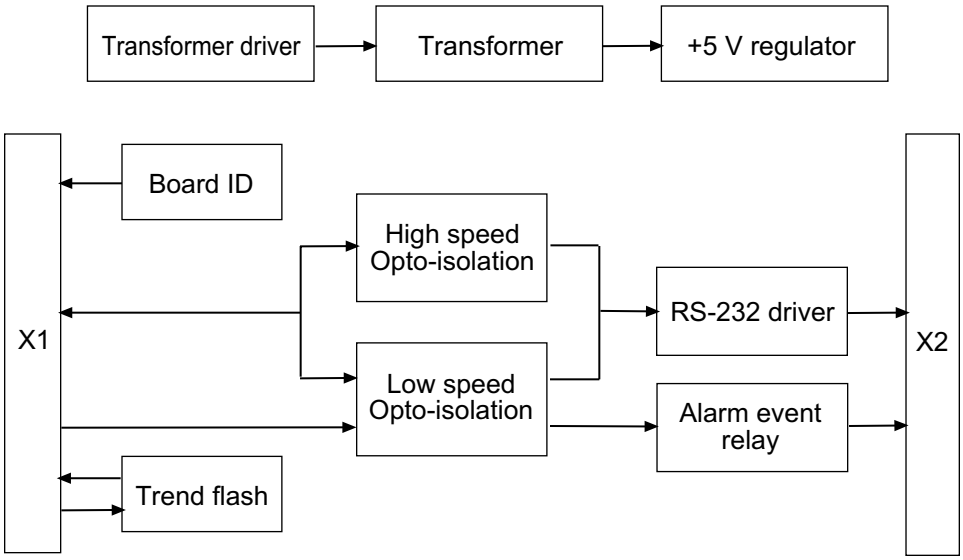


Figure 2-4. Trend Download board block diagram

The Trend Download board provides an interface for connecting a personal computer or printer to the monitor. It contains a board ID circuit, a flash memory IC for trend storage, an isolation transformer for isolated power, a 2500 VAC isolation barrier to SIP/SOP, an RS-232 level translator, and a Normally-Open Reed Relay contact used for alarm event annunciation.

The Trend Download board is powered by an isolated power supply consisting of a switching transformer that runs at 250 KHz, a 2500 VAC isolated transformer, and circuitry that provides 6.5 VDC raw voltage output to the secondary. A regulator provides a 5 VDC regulated supply for the secondary. The regulator delivers 1 A of current, but the secondary typically draws 10 mA (40 mA when the alarm event relay is energized).

The board ID circuit identifies the configuration of the Trend Download board. When no jumpers are installed (default configuration), a 1.5 VDC output is read by the microcontroller on the System board. On future Trend Download boards, the output will depend on the location of jumpers.

Up to 48 hours of trend data can be stored in a 2 MB (256K X 8) flash memory IC on the Trend Download board through an SPI bus interface on the System board. The flash memory buffer ensures data retention without battery backup.

All RS-232 signals are translated to a ± 7 V level by a chip with a built-in power supply that generates ± 7 V from a single 5 VDC power input. Two high-speed opto-isolators are connected to the RS-232 RXD and TXD signals. Two low-speed opto--isolators are connected to the RS-232 CTS and RTS signals.

Alarm event relay

The alarm event circuit contains a normally-open relay switch that closes in the event of an alarm condition and remains closed until the alarm condition ends. When S1 is switched to “enable,” a multiple-component circuit responds to an incoming signal, energizes the relay coil, and closes the contact between pin 1 and pin 3 of the RS-232 DIN 6 connector (X2). The contact rating is 0.5 A @ 200 VAC.

For power conservation, S1 is set to “disable” by default, meaning alarm annunciation is disabled. When the relay is energized, the board draws additional power each time an alarm condition is active.

The alarm event relay and the RS-232 output, are isolated from the monitor and from the patient to eliminate the possibility of ground loops. For over-current safety, the relay switch is protected by a 1 A fuse (in fuse block F2). If overload from the “nurse call” system blows the fuse, it can be replaced with a fuse of the same type and rating.

3. TROUBLESHOOTING

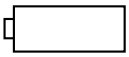
This chapter contains:

- A guide for troubleshooting problem situations.
- Board drawings, test points, and connector pin assignments.

3.1 Troubleshooting guide

The following chart lists situations that may occur while using the monitor. Follow the recommended action in the order listed until the cause is isolated and corrected.

NOTE: Procedures for replacing monitor parts are in the *Service Procedures* chapter.

Situation	Cause	Action
– – – Dashes are displayed for measurement.	Poor signal quality caused by a disconnected or improperly applied sensor, low perfusion, or interfering substances (such as excessive ambient light, nail polish, or an electrosurgical device). Overlapping cables or a device connected to the RS-232 port can also cause interference.	Check the sensor connection and placement. Change the site or use a different style of sensor in the presence of continuous, severe motion. Remove sources of interference. Make sure cables do not overlap. Disconnect the cable from RS-232 port. Disconnect the power cable from the monitor and use battery power.
	Signal interference due to an incorrect line power frequency setting.	Set the line power frequency to match your local AC power source (50 Hz or 60 Hz). See *Functional check* in the *Service Procedures* chapter.
	Signal interference due to poor grounding at AC power source.	Use a grounded AC power source or use battery power.
	Signal interference due to adjacent sensors (two or more SpO_2 sensors on the same hand or foot, for example).	Apply only one sensor to the hand, foot, or any other site.
 Flashes ON/OFF.	Low battery. Monitor can be powered by battery only 10 to 60 minutes longer. NOTE: Press the Alarm Silence button once to cancel the alarm.	Connect the monitor to external power as soon as possible to recharge the battery. NOTE: When the battery is completely depleted, all display and measurement functions are switched OFF and a continuous tone sounds.
Start-up tones did not sound.	Speaker is disconnected or faulty.	Connect the speaker cable to the System board. Power ON. If the tones do not sound, replace the speaker.
	Alarm system failure.	Replace the System board.
Power supply cable disconnects easily from the power jack.	If the pin inside the power jack is slotted, the sides of the pin may be pressed together.	To expand the slot, slowly insert a very small flat-blade screwdriver into the slot and gently move it from side to side.
	Damaged or worn power jack.	Replace the power jack assembly.

Situation	Cause	Action
Green LED remains ON when monitor is disconnected from external power.	Display board malfunction.	Replace the Display board.
	System board failure.	Replace the System board.
Display is blank. Continuous tone may sound.	Software or hardware malfunction.	Press the Alarm Silence button once to cancel the alarm. Power OFF, then ON again.
	Battery is completely depleted.	Charge the battery for up to 30 minutes before attempting to power ON. NOTE: After recharging the battery, it may be necessary to cycle power ON/OFF several times.
	Battery failure.	Replace the battery pack.
	Display board failure.	Replace the Display board.
	System board failure.	Replace the System board.
Monitor will not power ON.	Battery is completely depleted. NOTE: The battery can become completely depleted when the monitor is unused for several months, especially if stored at high temperatures.	Connect the monitor to external power; verify that the green power light is ON. Charge the battery for up to 30 minutes before attempting to power ON. NOTE: After recharging a battery that was completely depleted, it may be necessary to cycle power ON/OFF several times.
	Battery is disconnected.	Connect the battery to the System board.
	Battery failure.	Check the battery voltage. If it is 3.2 V or less, the battery has failed; replace the battery.
	System board failure.	Replace the System board.
Monitor is connected to external power but green LED is OFF.	Power cord failure.	Check the power cord; replace if necessary.
	Line power is disconnected.	Check the external connections between the power source, the power supply, and the monitor. Check the internal connection of the line power cable to the System board.
	Line power cable is not connected or is improperly connected.	Check the internal connection of the line power cable to the System board.
	Power supply failure.	Check the power supply voltages of the power supply connector (12 V). Replace the power supply.
	Display board LED malfunction.	Replace the Display board.
	System board failure.	Replace the System board.
Monitor is connected to external power but will not power ON.	Monitor is trying to recharge a depleted or low battery.	Charge the battery for up to 30 minutes before attempting to power ON.
	Monitor is trying to recharge a battery that is faulty.	Replace the battery.
	System board failure.	Replace the System board.

Situation	Cause	Action
Power button or Alarm Silence button is not working.	Button is stuck due to debris (lint, for example); button is damaged or misaligned.	Clean the buttons and the power button pad. Check alignment; install buttons properly. Replace damaged button or button pad.
	Faulty switch on Display board.	Replace the Display board.
	System board malfunction.	Replace the System board.
No communication through RS-232 port.	Incorrect cable used to connect PC or printer to monitor.	PC—use only the TruSat/PC RS-232 cable supplied with the Trend Download option. Printer—use only the TruSat/serial printer cable supplied with the printer.
	Defective ribbon cable.	Replace the ribbon cable.
	Faulty RS-232 connector or Trend Download board.	Check the signal voltages and the wiring on the cable from the monitor to the connected device. Replace the Trend Download board.
Alarm signals are not being sent to the "nurse call" system.	Alarms have been silenced.	Press the Alarm Silence button to cancel the alarm silence.
	Blown fuse on Trend Download board.	Replace the relay switch fuse.

Error numbers

If either message listed below is displayed, first power OFF, then ON again. If the message reappears, note the error number displayed in the high SpO_2 alarm limit area and refer to the chart below for guidance.

Message	Error Number	Cause	Action
Prb	1–24, 26, 27	Faulty sensor.	Replace the sensor.
	25	Incompatible sensor.	Use only OxyTip+ sensors.
	28, 29	System board failure.	Replace the System board.
Err	27, 79, 81, 82	Software malfunction.	Install a software upgrade.
	83	Battery failure.	Replace the battery pack.
	89, 91, 117, 118	Serial communication error when printing or downloading.	Check cable and connections to printer/PC. Cycle power and retry.
	142	Trend memory malfunction.	Use the Trend Download software to erase trend memory.

NOTE: If any other number is displayed and/or if you are unable to correct the situation by cycling power to the monitor, note the error number and contact an authorized service representative for assistance.

3.2 System board components

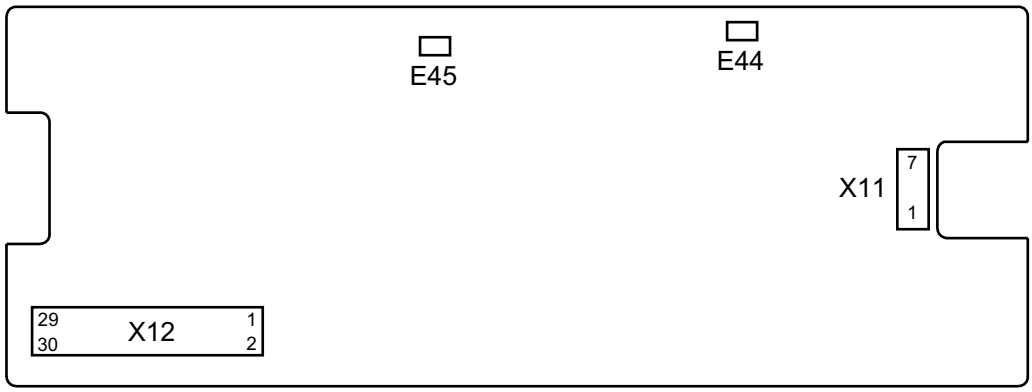


Figure 3-1. System board—front

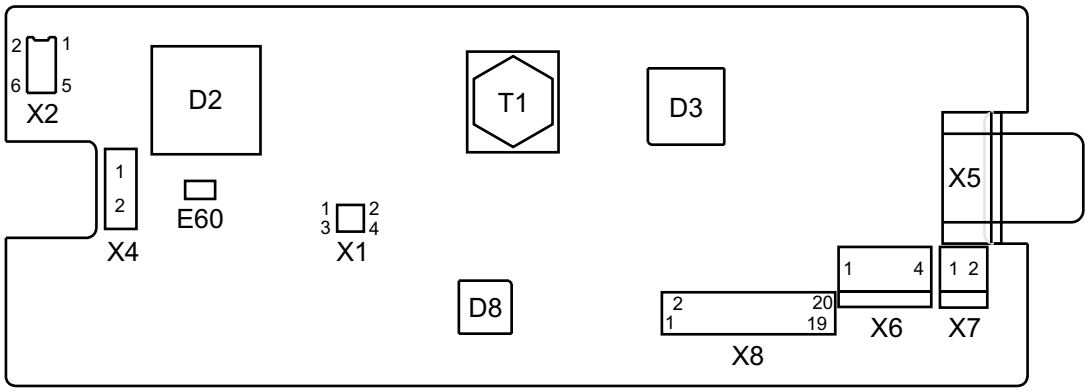


Figure 3-2. System board—back

D2 Digital signal processor (DSP)
D3 Complex programmable logic device (CPLD)
D8 Microcontroller
E44 Test point
E45 Test point
E60 Test point
T1 Transformer
X1 Jumper set, board configuration identification, 4 pin
X2 ComWheel connector, 6 pin
X4 Speaker connector, 2 pin
X5 Pulse oximetry connector, 9 pin
X6 Battery connector, 4 pin
X7 DC line power connector, 2 pin
X8 Trend Download board connector, 20 pin
X11 Software upgrade connector, 7 pin
X12 Display board connector, 30 pin

System board test points

Test point	Signal name	Description
E44	GND	Non-isolated/chassis ground
E45	GNDF	Isolated ground
E60	GND	Non-isolated/chassis ground

System board connectors

ID connector (X1)

Pin #	Signal Name	I/O	Description
1,2	Alternate board configuration B	A	A jumper across these two pins will identify a different board configuration
3,4	Alternate board configuration C	A	A jumper across these two pins will identify a different board configuration

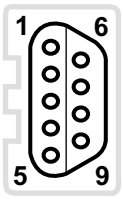
ComWheel connector (X2)

Pin #	Signal Name	I/O	Description
1	GND	GND	Non-isolated ground
2	GND	GND	Non-isolated ground
3	CW_PB+	I	COM wheel push button signal
4	CW_OUTB	I	Phase B ComWheel input signal
5	CW_OUTA	I	Phase A ComWheel input signal
6	CW_VCC	O	Modulated ComWheel power

Speaker connector (X4)

Pin #	Signal Name	I/O	Description
1	SPEAKER+	I	Differential positive speaker signal
2	SPEAKER–	O	Differential negative speaker signal

Pulse oximetry connector (X5)



Pin #	Signal Name	I/O	Description
1	PD_C	I	Photodiode cathode signal
2	GND	GND	Isolated ground
3	IR	I/O	IR LED anode, bi-directional current
4	RED	I/O	Red LED anode, bi-directional current
5	CATHODES	I/O	LED cathodes, bi-directional current
6	PD_A	I	Photodiode anode signal
7	GND	GND	Isolated ground
8	PRB_ID	I	Probe ID / Bin resistor signal
9	CATHODES	I/O	LED cathodes, bi-directional current

Battery connector (X6)

Pin #	Signal Name	I/O	Description
1	BATT–	PWR	Negative terminal of battery, current return
2	BATT+	PWR	Positive terminal of battery, current input
3	GND	GND	Non-isolated ground
4	NTC+	I	Battery thermistor

DC line power connector (X7)

Pin #	Signal Name	I/O	Description
1	+12VDC	PWR	+12 VDC nominal
2	GND	GND	Non-isolated ground

Trend Download board connector (X8)

Pin #	Signal Name	I/O	Description
1	VDD	PWR	+3 V power signal, isolated by ferrite
2	VDD	PWR	+3 V power signal, isolated by ferrite
3	OPT_BRD_ID	I	Trend Download board ID, analog signal
4	SPI_UP_DOUT_BUFF	O	SPI data-out signal, isolated by buffer
5	GND	GND	Non-isolated ground
6	SPI_UP_DIN_BUFF	I	SPI data-in signal, isolated by buffer
7	GND	GND	Non-isolated ground
8	SPI_CLK_BUFF	O	SPI clock, isolated by buffer
9	GND	GND	Non-isolated ground
10	$\overline{\text{SPI_CS_OPTION0}}$	O	SPI chip select 0
11	$\overline{\text{SPI_CS_OPTION1}}$	O	SPI chip select 1
12	GND	GND	Non-isolated ground
13	UART_TXD	O	RS-232 transmit data
14	UART_RXD	I	RS-232 receive data
15	UART_CTS	I	RS-232 hardware handshaking
16	UART_RTS	O	RS-232 hardware handshaking
17	GND	GND	Non-isolated ground
18	NURSE_CALL	O	"Nurse call" alarm signal
19	BATT+	PWR	Battery voltage, isolated by ferrite
20	BATT+	PWR	Battery voltage, isolated by ferrite

Software upgrade connector (X11)

Pin #	Signal Name	I/O	Description
1	GND	GND	Non-isolated ground
2	SPI_UP_DIN	I	SPI serial data input
3	SPI_UP_DOUT	O	SPI serial data output
4	SPI_CK	O	SPI clock
5	$\overline{\text{UP_CS_UPG_FL}}$	O	Program upgrade flash chip select
6	VDD	PWR	+3 V power signal
7	GND	GND	Non-isolated ground

Display board connector (X12)

Pin #	Signal Name	I/O	Description
1	V_ON	PWR	+3 V regulated voltage from DC line
2	GND	GND	Non-isolated ground
3	BACKLIGHT_CUR	O	Backlight supply current
4	BACKLIGHT_CUR	O	Backlight supply current
5	BACKLIGHT_RET_CUR	I	Backlight return current
6	BACKLIGHT_RET_CUR	I	Backlight return current
7	BATT+	PWR	Battery voltage, isolated by ferrite
8	GND	GND	Non-isolated ground
9	$\overline{\text{LCD_EN}}$	O	Enable signal for Display board regulator
10	GND	GND	Non-isolated ground
11	GRN_AC_LED	O	Supply voltage for DC line power LED
12	GND	GND	Non-isolated ground
13	SPARE_KEY0	I/O	Unused
14	GND	GND	Non-isolated ground
15	SPARE_KEY1	I/O	Unused
16	GND	GND	Non-isolated ground
17	I2C_SDAT	O	I^2C bus, serial data
18	GND	GND	Non-isolated ground
19	I2C_SCLK	O	I^2C bus, serial clock
20	GND	GND	Non-isolated ground
21	ALARM_SW	I	Alarm button signal, active high
22	GND	GND	Non-isolated ground
23	ON/OFF	I	Power button signal, active low
24	GND	GND	Non-isolated ground
25	ALARM_LED_RED	O	Alarm LED, red
26	GND	GND	Non-isolated ground
27	ALARM_LED_YEL	O	Alarm LED, yellow
28	GND	GND	Non-isolated ground
29	V_ON	PWR	+3V regulated voltage from DC line
30	GND	GND	Non-isolated ground

3.3 Display board components

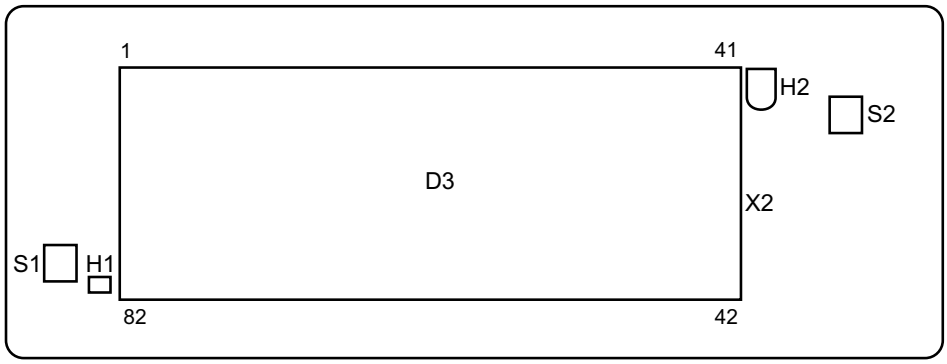


Figure 3-3. Display board—front

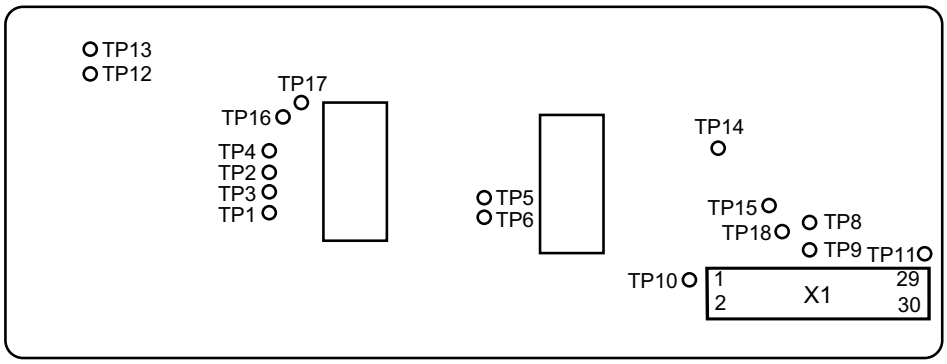


Figure 3-4. Display board—back

D3 LCD
H1 LED, external power, green
H2 LED, alarm, bicolor, red/yellow
S1 Power button switch
S2 Alarm Silence button switch
X1 Connector, board-to-board, 30 pin
X2 Backlight

Display board test points

NOTE: TP7 is not used. TP1 through TP6, TP8, and TP9 are for unused pins.

Test point	Signal name	Description
TP10	V_ON	3 V continuous supply
TP11	V_ON	3 V continuous supply
TP12	ALARM_LED_RED	Red alarm LED
TP13	ALARM_LED_YEL	IR alarm LED
TP14	FB	Feedback for TPS77001 regulator (1.22 V)
TP15	BATT+	Battery + terminal
TP16	$\overline{\text{LCD_EN}}$	Enables the 4.2 V regulator for display drivers
TP17	CLK	Display driver chip; external clock input for display driver
TP18	$\overline{\text{sync}}$	Display driver chip; cascade synchronization IN/OUT

Display board connector

System board connector (X1)

Pin #	Signal Name	I/O	Description
1	V_ON	I	+3 V regulated voltage from DC line
2	GND	GND	Non-isolated ground
3	BACKLIGHT_CUR	I	Backlight supply current
4	BACKLIGHT_CUR	I	Backlight supply current
5	BACKLIGHT_RET_CUR	O	Backlight return current
6	BACKLIGHT_RET_CUR	O	Backlight return current
7	BATT+	I	Battery voltage, isolated by ferrite
8	GND	GND	Non-isolated ground
9	$\overline{\text{LCD_EN}}$	I	Enable signal for Display board regulator
10	GND	GND	Non-isolated ground
11	GRN_AC_LED	I	Supply voltage for DC line power LED
12	GND	GND	Non-isolated ground
13	SPARE_KEY0	I/O	Unused
14	GND	GND	Non-isolated ground
15	SPARE_KEY1	I/O	Unused
16	GND	GND	Non-isolated ground
17	I2C_SDAT	I	I^2C bus, serial data
18	GND	GND	Non-isolated ground
19	I2C_SCLK	I	I^2C bus, serial clock
20	GND	GND	Non-isolated ground
21	ALARM_SW	O	Alarm button signal, active high
22	GND	GND	Non-isolated ground
23	ON/OFF	O	Power button signal, active low
24	GND	GND	Non-isolated ground
25	ALARM_LED_RED	I	Alarm LED, red
26	GND	GND	Non-isolated ground
27	ALARM_LED_YEL	I	Alarm LED, yellow
28	GND	GND	Non-isolated ground
29	V_ON	I	+3 V regulated voltage from DC line
30	GND	GND	Non-isolated ground

3.4 Trend Download board (RS-232) components

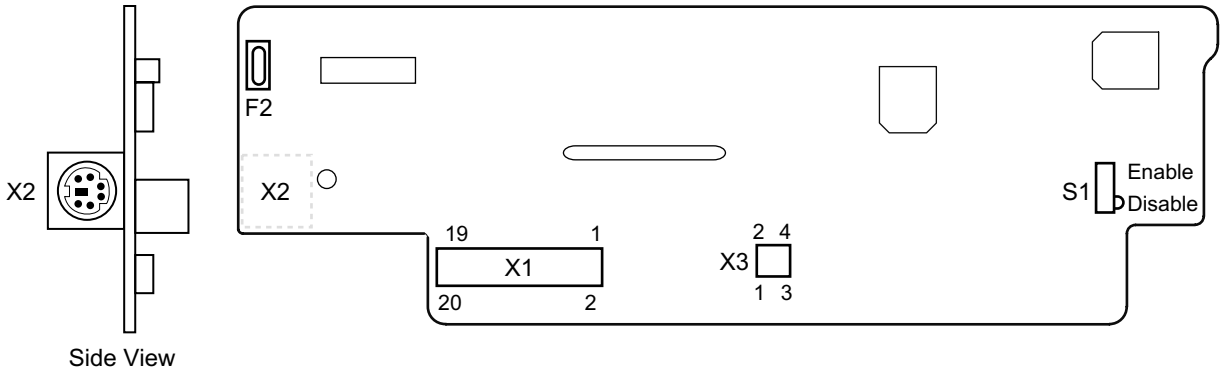


Figure 3-5. Trend Download board

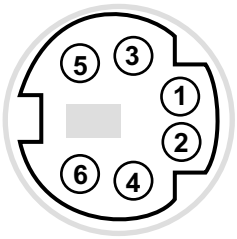
F2 Fuse block and fuse for alarm relay switch
S1 Alarm relay enable/disable switch
X1 Connector, Trend Download board to System board, 20 pin
X2 Connector, RS-232 Din 6
X3 Jumper set, board configuration identification, 4 pin

Trend Download board connectors

System board connector (X1)

Pin #	Signal Name	I/O	Description
1	VDD	PWR	+3 V power signal, isolated by ferrite
2	VDD	PWR	+3 V power signal, isolated by ferrite
3	OPT_BRD_ID	O	Trend Download board ID, analog signal
4	SPI_DIN	I	SPI data in signal
5	GND	GND	Non-isolated ground
6	SPI_DOUT	O	SPI data out signal
7	GND	GND	Non-isolated ground
8	SPI_CLK	I	SPI clock
9	GND	GND	Non-isolated ground
10	$\overline{\text{SPI_CS_OPTION0}}$	I	SPI chip select 0
11	$\overline{\text{SPI_CS_OPTION1}}$	I	SPI chip select 1
12	GND	GND	Non-isolated ground
13	UART_TXD	I	RS-232 transmit data
14	UART_RXD	O	RS-232 receive data
15	UART_CTS	O	RS-232 hardware handshaking
16	UART_RTS	I	RS-232 hardware handshaking
17	GND	GND	Non-isolated ground
18	ALARM_EVENT	I	Alarm event annunciation
19	V_BATT	PWR	Battery voltage
20	V_BATT	PWR	Battery voltage

RS-232 connector (X2)



Pin #	Signal Name	I/O	Description
1	ALARM_EVENT	O	Alarm event output
2	TXD	O	Transmit data
3	GND	GND	GND connection
4	RTS	O	Ready to send (RTS)
5	CTS	I	Clear to send (CTS)
6	RXD	I	Receive data

ID connector (X3)

Pin #	Signal Name	I/O	Description
1,2	Alternate board configuration B	A	A jumper across these two pins will identify a different board configuration
3,4	Alternate board configuration C	A	A jumper across these two pins will identify a different board configuration

4. SERVICE PROCEDURES

This chapter contains procedures for the following:

- Checking the operation of the monitor.
- General maintenance.
- Installing upgrades, including software and the Trend Download option.
- Alarm annunciation setup for monitors with the Trend Download option.
- Replacing parts.

CAUTION: Only qualified service personnel should perform the procedures described in this manual.

4.1 Functional check

If the monitor is disassembled for any test or repair procedure, always verify that the monitor is functioning properly before returning it for patient monitoring.

WARNING: Do not use the monitor if the startup tones do not sound, the validity of data is questionable, or if the monitor fails to function as described. Refer to the appropriate sections of this manual to identify and correct the malfunction.

1. Plug the power supply cable into the power connector on the monitor. Then, connect the power supply to the power outlet.

Important: If you are preparing the monitor for first-time use or have just removed it from extended storage, charge the battery for three hours BEFORE you power ON.

2. Power ON the monitor. Check for the following during startup:

   - The power-on tones sound.
   - All display elements, including on-screen controls, illuminate briefly.
   - The alarm LED is lit red, then yellow.
   - The backlight is ON until dashes are displayed for the SpO_2 and pulse rate. The backlight remains ON if it is set to ON.
   - A patient number (P01, P02, etc.) is displayed if the Trend Download board is installed.

   NOTE: During power-on, monitor self-tests check electronics, battery status, and calibration. Upon successful completion of all self-tests, the monitor is considered to be in calibration and ready for normal operation.

3. Power OFF and check the line power filter setting shown in the high pulse rate alarm area: **50** (Hz) or **60** (Hz). If the setting matches your local AC line power frequency, go to the next step. If it is different, go to *Changing the line power filter* before you continue with the next step.

4. Choose a sensor designed for use on a finger, place it on your finger, and connect it to the monitor. Power ON.

   NOTE: All pleth bar segments pulsate until the measured values are displayed.

5. When the SpO_2 and pulse rate values are displayed, verify that the lowest pleth bar segment remains visible while one or more of the other segments pulsate.

6. Remove the sensor from your finger. Verify that the alarm LED flashes red, an alarm tone sounds, and dashes replace the SpO_2 and pulse rate values.

7. Place the sensor on your finger again. After the SpO_2 and pulse rate values are displayed, unplug the sensor from the monitor. Verify that the alarm LED flashes red, an alarm tone sounds, and dashes replace the values.

8. Press, then turn the ComWheel until the pointer is above PI_r. Press the ComWheel and verify that the PI_r value is displayed.

   NOTE: Press the ComWheel to exit the PI_r display.

9. Check the battery indicator. If the battery is low, recharge the battery before using it to power the monitor.

10. If the monitor is configured with the Trend Download option, check the clock settings. Go to *Setting the clock*.

Important: DO NOT use the monitor if it fails to function as described. To identify and correct the problem, refer to the *Troubleshooting* chapter.

Changing the line power filter

For the best low perfusion performance, set the line power filter to match the line power frequency of your local AC power source. The software line power filter will then eliminate potential interference when you use AC power or when you use battery power near an AC power source.

1. To change the line power filter setting, power ON the monitor. Press the ComWheel seven times, holding it in on the seventh press until the new setting is displayed: 50 H(z) or 60 H(z).

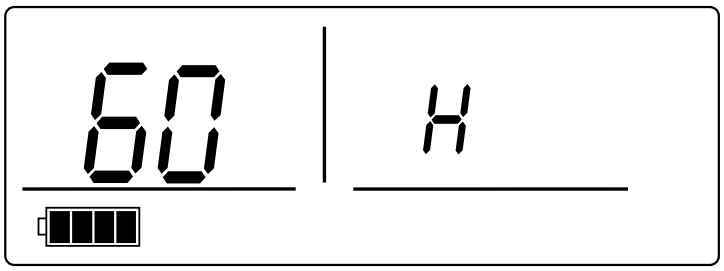


Figure 4-1. Changing the line power filter

2. To check the setting, power OFF and verify that the new setting is displayed in the high pulse rate alarm area.

Setting the clock

You can set the monitor clock only if a Trend Download board is installed in your monitor.

Set the clock:

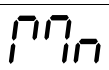
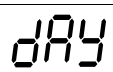
- After repairing a monitor that contains the Trend Download board.
- After installing the Trend Download upgrade.

Important: Clock settings are lost when the battery is disconnected or fails. Set the clock to ensure that the Trend Download board is functioning properly and that all patient records contain the correct time and date.

NOTE: The Trend Download PC software can also be used to set the clock.

1. Power OFF, unplug the sensor from the monitor, and power ON.
2. Press the ComWheel three times, holding it in for five seconds on the third press.

   Each clock option (year, month, etc.) is displayed sequentially in the pulse rate field. The setting (3, 12, etc.) is displayed in the SpO_2 field. The time is based on a 24-hour clock.

When you see ...	You can choose ...
	year (0–99)
	month (1–12)
	day (1–31)

When you see ...	You can choose ...
	hour (0–23)
	minute (0–59)
	exit

3. Turn, then press the ComWheel to select a clock option. The selected option flashes ON/OFF. Turn, then press the ComWheel to select the setting for that option. Repeat to set each clock option.
4. When you are finished, use the ComWheel to select exit.

Electrical safety check

WARNING: Measure the leakage current(s) in accordance with applicable standards after completing any repair procedure.

1. Following applicable standards, use the instructions supplied with the leakage current tester to measure the leakage current(s).
2. Record the results for comparison with future leakage current tests.

Ground resistance test

A case ground resistance test is not necessary or appropriate because the TruSat is a SELV (Safety Extra Low Voltage) device as defined in EN 60601-1, Clause 2.4.2. The monitor is powered by an external DC SELV (12 V) power supply. Since the monitor does not contain an internal AC power supply, the case is not required to be protectively earthed. If a ground resistance test is performed on the monitor, the resistance measurement may be erroneous.

4.2 Planned Maintenance

Preventive maintenance and/or calibration are not required for the TruSat pulse oximeter.

Battery

To extend the life of the battery:

- Fully charge the battery once a month.

  NOTE: After all four battery segments are shaded, wait at least 20 minutes before you disconnect the monitor from the external power source. This allows time for the monitor to refresh the battery.

- Fully discharge the battery once every six months.

To discharge the battery, use battery power for monitoring until only one segment of the battery indicator is shaded. Then, connect the monitor to external power and fully recharge the battery.

NOTE: The battery can be recharged only when the internal temperature of the monitor is between 0 °C and 40 °C (32 to 104 °F).

Cleaning

Clean the monitor before starting a procedure that involves disassembly of the monitor and before sending the monitor for repair.

CAUTION: Do not autoclave, pressure sterilize, or gas sterilize the monitor. Do not immerse the monitor in liquid or allow liquid to enter the interior.

CAUTION: Abrasive materials or harsh chemicals may damage the surface of the monitor. Do not use petroleum-based solutions or solutions containing acetone, freon, or harsh solvents.

1. Power OFF the monitor.
2. Disconnect all cables from the monitor: power supply, sensor, and any cable connected to the RS-232 port.
3. Wipe the display lens with a cotton swab moistened with one of the following cleaning agents:

Mild detergent solution	0.5% sodium hypochlorite (bleach)
70% isopropyl alcohol	Quarternary germicides (Virex®)
1.6% phenol (Sporicidin®)	3.4% glutaraldehyde (Cidex® Plus)

4. Wipe the case with a soft cloth dampened with a cleaning agent. Do not allow excess liquid to enter through a connector.

NOTE: To clean a reusable sensor, refer to the instructions that are provided with the sensor. Disposable sensors are intended for single-patient use only and should be discarded after use.

4.3 Software upgrade

The software upgrade kit includes an upgrade card that contains current versions of the oximetry, system, and other monitor software. You upgrade the software by inserting this card into a connector located on the System board.

Checking the current software versions

1. Power ON the monitor. Then power OFF and note the software version numbers that display briefly:

   - The oximetry software version number displays in the SpO_2 display area.
   - The system software version number displays in the pulse rate display area.

   NOTE: You will also see "50" or "60" in the high pulse rate alarm area. This is the line power filter monitor setting that is set to match the AC power source.

2. If either software version is below the version noted on the software upgrade label, install the software upgrade.

Installing the software upgrade

WARNING: Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

Tool: Phillips screwdriver, #1

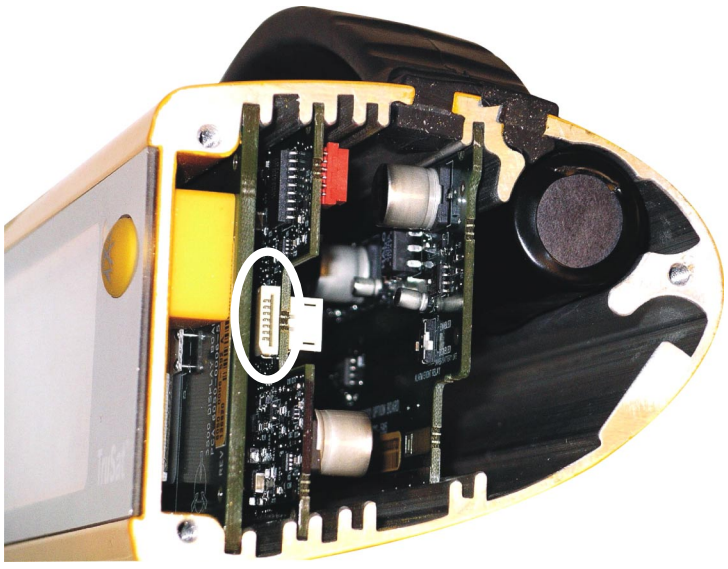


Figure 4-2. Software upgrade connector on System board

1. Power OFF and disconnect the power cord and other cables from the monitor.
2. On the right (ComWheel) side of the monitor, loosen the 3 screws until you can lift the bumper assembly away from the housing.

3. Note the orientation of the ComWheel encoder cable and the speaker cable. Each is "keyed" for correct connection to the System board. Carefully disconnect both cables from the System board and remove the bumper assembly.
4. Locate the software upgrade connector on the System board. It is circled in Figure 4-2.
5. Orient the upgrade card with the "chip" facing toward the front of the monitor. Insert the card into the connector.
6. Power ON the monitor.

   Individual segments of each seven-segment LED in the SpO_2 display area flash ON/OFF in a circular pattern until the upgrade is complete.

   NOTE: If you do not see this pattern the card was inserted incorrectly. Power OFF and remove the card. Reinsert the card with the "chip" facing toward the front of the monitor. Then, power ON to start the upgrade.
7. When the upgrade is complete, first remove the upgrade card. Then, power OFF and verify that the displayed software version numbers match the version numbers on the upgrade.

   NOTE: If the displayed version numbers do not match the upgrade version numbers, repeat the upgrade. When the upgrade is complete, be sure to remove the upgrade card BEFORE you power OFF.
8. Connect the speaker cable and the ComWheel encoder cable to the System board. Position the cables inside the housing to ensure they will not be pinched.
9. Place the bumper assembly over the housing and tighten the 3 screws.

Important: Test the monitor. See *Functional check* earlier in this chapter.

4.4 Trend Download upgrade

The items listed below are included in the Trend Download upgrade kit:

- Trend Download board
- Ribbon cable
- Left bumper for RS-232 connector
- Compact disc (CD) containing Trend Download PC software and instructions
- TruSat/PC RS-232 cable

The instructions that follow are for installing the Trend Download board only.

- For information about using the printer and/or the Trend Download software, refer to the *TruSat User's Guide*.
- For information about customizing a cable and enabling the alarm annunciation feature, see *Alarm annunciation* later in this chapter.

NOTE: You can enable the alarm annunciation feature before or after installing the Trend Download board. For details, see *Alarm annunciation* later in this chapter.

Installing the Trend Download board

WARNING: Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

Tool: Phillips screwdriver, #1

1. Power OFF and disconnect the power cord and other cables from the monitor.
2. On the right (ComWheel) side of the monitor, loosen the 3 screws until you can lift the bumper assembly away from the housing.
3. Note the orientation of the ComWheel encoder cable and the speaker cable. Each is "keyed" for correct connection to the System board. Carefully disconnect both cables from the System board and remove the bumper assembly.
4. On the left side of the monitor, remove the 3 screws and set the bumper assembly parts aside.
5. Push the Display board and the System board (as a unit) from the right side of the housing out the left side until you can easily disconnect the line power cable and battery cable from the System board. Disconnect both cables.
6. Note which slots in the housing are used for the boards. Then, slide the boards all the way out the left side of the housing.

   NOTE: If you dislodge the Alarm Silence button, the power button, and/or the power button pad, set the part(s) aside until you reinstall the boards.
7. Connect the ribbon cable to the Trend Download board and to the System board.
8. Position all three boards in their slots in the left side of the housing. Slowly slide the boards (as a unit) into the housing until you can easily connect the battery cable and the line power cable to the System board. Connect the cables.
9. Slide the boards all the way into the housing. Reposition the Alarm Silence button, the power button, and the power button pad, as needed.
10. Remove the SpO_2 connector code ring from the old left bumper and install it in the new bumper. Place the inner left end plate over the code ring.
11. Position the left bumper assembly over the left side of the housing, holding the inner left end plate in place. Place the outer end plate over the left bumper and install the 3 screws that secure the bumper assembly to the housing.
12. At the right side of the housing, connect the speaker cable and the ComWheel encoder cable to the System board. Position the cables inside the housing to ensure they will not be pinched.
13. Place the right bumper assembly over the housing and tighten the 3 screws.

Important: Test the monitor and set the monitor clock. See *Functional check* earlier in this chapter.

4.5 Alarm annunciation

The TruSat Trend Download board (RS-232) is equipped with an alarm annunciation capability for use with your existing "nurse call" system. If the Trend Download board is installed in your monitor, you must do the following to use this feature:

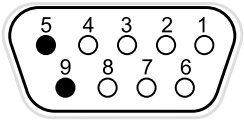
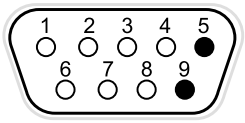
- Customize a cable in order to connect the monitor to your system.
- Change a switch setting on the Trend Download board to enable the feature.

Customizing a cable

The Trend Download board contains a relay contact connected across two pins of the RS-232 DIN 6 circular connector. During an alarm event, the relay switch closes the circuit between these two pins. This closed relay contact is rated to 0.5 A and 200 VAC.

You can access the two sides of the relay contact through the DIN 6 connector or the DB9 connector on the TruSat/PC RS-232 cable (supplied with the Trend Download upgrade) or on the TruSat/serial printer cable (supplied with the optional printer).

- DIN 6 connector—Connect to pins 1 and 3 using either cable.
- DB9 connector—Connect to pins 5 and 9 using either cable.

DIN 6 (both cables)	**DB9 on TruSat/PC RS-232 cable 6050-0006-924**	**DB9 on TruSat/serial printer cable 6050-0006-925**
Male DIN 6 – Front view	 Female DB9 – Front view	 Male DB9 – Front view
Pin 1: Alarm event output Pin 2: Transmit Pin 3: Ground Pin 4: Ready to send (RTS) Pin 5: Clear to send (CTS) Pin 6: Receive	Pin 1: Unused Pin 2: Receive Pin 3: Transmit Pin 4: Data terminal ready (DTR) * Pin 5: Ground Pin 6: Data set ready (DSR) * Pin 7: Ready to send (RTS) Pin 8: Clear to send (CTS) Pin 9: Alarm event output	Pin 1: Unused Pin 2: Transmit Pin 3: Receive Pin 4: Data terminal ready (DTR) * Pin 5: Ground Pin 6: Data set ready (DSR) * Pin 7: Clear to send (CTS) Pin 8: Ready to send (RTS) Pin 9: Alarm event output

* Pin 4 is tied to pin 6 (shorted together) on the DB9 connector.

Enabling alarm annunciation

To conserve battery power, DISABLED is the default setting for the alarm event switch on the Trend Download board. Change the switch setting to ENABLED only if you have customized a cable and intend to connect the monitor to your local "nurse call" system.

- If you are installing a new Trend Download board, you can change the switch setting before completing the installation. See *Before installing the Trend Download board*.
- If the Trend Download board is already installed, see *After installing the Trend Download board*.

Before installing the Trend Download board

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

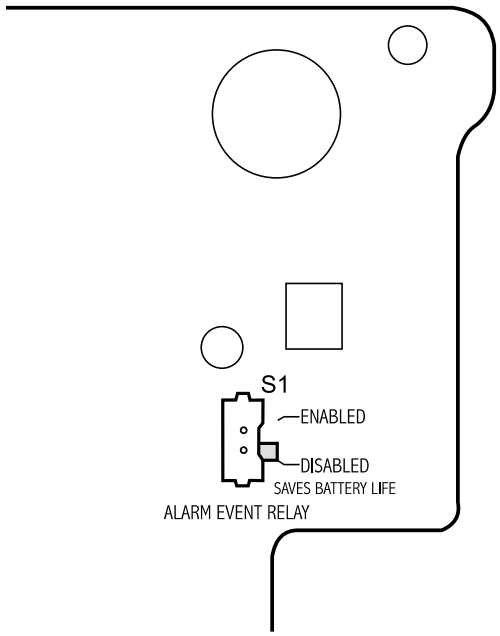


Figure 4-3. Alarm event switch on Trend Download board

To enable the alarm annunciation feature on a new Trend Download board, gently move the white lever to the ENABLED position. Figure 4-3 shows the DISABLED (factory default) position.

After installing the Trend Download board

WARNING: Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

Tool: Phillips screwdriver, #1

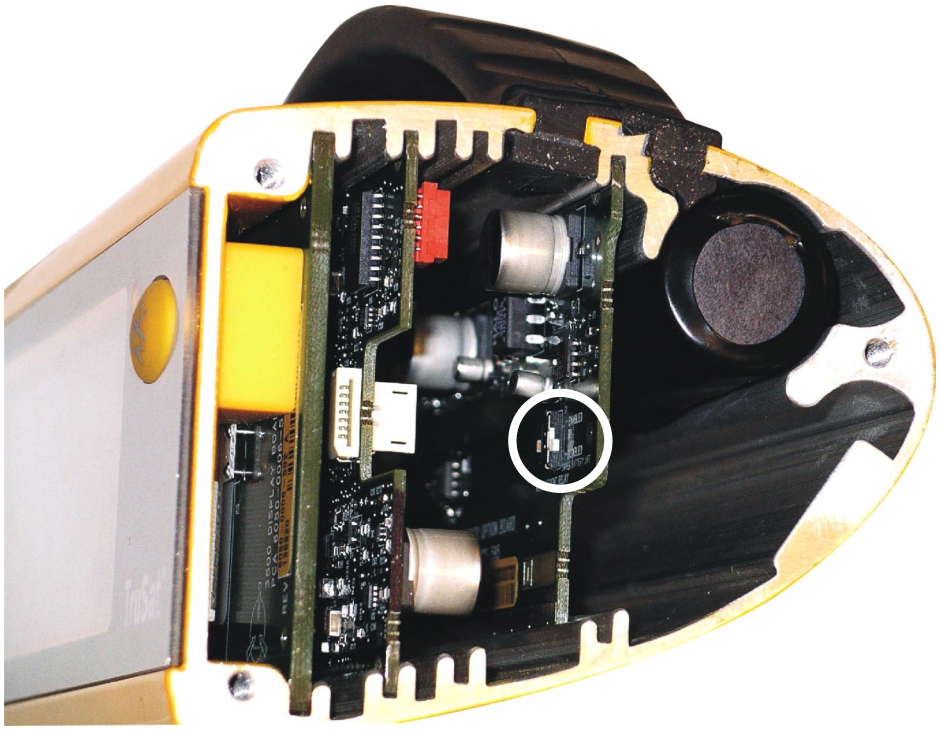


Figure 4-4. Alarm event relay switch (S1) in the DISABLED position

1. Power OFF and disconnect the power cord and other cables from the monitor.
2. On the right (ComWheel) side of the monitor, loosen the 3 screws until you can lift the bumper assembly away from the housing.
3. Note the orientation of the ComWheel encoder cable and the speaker cable. Each is "keyed" for correct connection to the System board. Carefully disconnect both cables from the System board and remove the bumper assembly.
4. Locate the alarm event relay switch on the Trend Download board. It is circled in Figure 4-4. Gently move the white lever to the ENABLED position.
5. Connect the speaker cable and the ComWheel encoder cable to the System board. Position the cables inside the housing to ensure they will not be pinched.
6. Place the bumper assembly over the housing and tighten the 3 screws.

Important: Test the monitor. See *Functional check* earlier in this chapter.

Relay switch fuse replacement

If overload from the "nurse call" system blows the relay switch fuse on the Trend Download board, replace the fuse with a fuse of the same type and rating.

WARNING: Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

Tools:

- Phillips screwdriver, #1
- Needle-nose pliers

1. Power OFF and disconnect the power cord and other cables from the monitor.
2. On the right (ComWheel) side of the monitor, loosen the 3 screws until you can lift the bumper assembly away from the housing.
3. Note the orientation of the ComWheel encoder cable and the speaker cable. Each is "keyed" for correct connection to the System board. Carefully disconnect both cables from the System board and remove the bumper assembly.
4. On the left side of the monitor, remove the 3 screws and the left bumper assembly.
5. Push all the boards (as a unit) from the right side of the housing out the left side until you can easily disconnect the line power cable and the battery cable from the System board. Disconnect the cables.
6. Note which slots in the housing are used for the boards. Then, slide the boards all the way out the left side of the housing.

   NOTE: If you dislodge the Alarm Silence button, the power button, and/or the power button pad, set the part(s) aside until you reinstall the boards.
7. Disconnect the ribbon cable from the Trend Download board.
8. Using a needle-nose pliers, replace the fuse at F2 on the Trend Download board.
9. Connect the ribbon cable to the Trend Download board.
10. Position all three boards in their slots in the left side of the housing. Slowly slide the boards (as a unit) into the housing until you can easily connect the battery cable and the line power cable to the System board. Connect the cables.
11. Slide the boards all the way into the housing. Reposition the Alarm Silence button, the power button, and the power button pad, as needed.
12. Position the left bumper assembly over the left side of the housing, holding the inner left end plate in place. Place the outer end plate over the left bumper and install the 3 screws that secure the bumper assembly to the housing.
13. At the right side of the housing, connect the speaker cable and the ComWheel encoder cable to the System board. Position the cables inside the housing to ensure they will not be pinched.
14. Place the right bumper assembly over the housing and tighten the 3 screws.

Important: Test the monitor. See *Functional check* earlier in this chapter.

4.6 Repair procedures

WARNING: Power OFF and disconnect the monitor from external power before performing any procedure that involves disassembly of the monitor.

WARNING: Internal electronic components are susceptible to damage by electrostatic discharge. To avoid damage when disassembling the monitor, observe the standard precautions and procedures for handling static-sensitive components.

Tools:

- Phillips screwdriver, #1
- Small, flat-blade screwdriver
- Nut drivers, 3/8 inch (for line power jack) and 7/16 inch (for ComWheel encoder)

Monitor disassembly

Disassemble the parts on the right side, the left side, and within the housing only as needed to access the part or parts to be replaced. Then go to the assembly instructions to complete the procedure.

Refer to the assembly drawing as you disassemble the monitor. See *TruSat assembly drawing* later in this manual.

Right (ComWheel) side disassembly

Parts:

Right bumper	Speaker
Right inner end plate	ComWheel knob
ComWheel encoder (with spacer, washer, and nut)	Outer end plate

1. Power OFF and disconnect the power cord and other cables from the monitor.
2. Remove the 3 screws that secure the right bumper assembly to the housing.
3. Note the orientation of the ComWheel encoder cable and the speaker cable. Each is "keyed" for correct connection to the System board. Carefully disconnect both cables from the System board.
4. Using a small, flat-blade screwdriver, gently pry the edges of the ComWheel knob away from the bumper. Grasp the ComWheel and pull it off the encoder post.
5. Lift the right inner end plate out of the bumper. Using a 7/16 inch nut driver, remove the nut and washer that secure the ComWheel encoder to the end plate. Slide the encoder and spacer out the other side of the end plate.
6. Lift the speaker out of the bumper.

Left side disassembly

Parts:

Left bumper	Left inner end plate
SpO_2 code ring	Outer end plate

1. Remove the 3 screws that secure the left bumper assembly to the housing.
2. Lift the left inner end plate out of the bumper and remove the SpO_2 code ring from the bumper.

Housing disassembly

Parts:	Power button pad	Display board	Battery
	Power button	System board	Line power hardware
	Alarm Silence button	Trend Download board	Handle and housing

1. Push all the boards (as a unit) from the right side of the housing out the left side until you can easily disconnect the line power cable and the battery cable from the System board. Disconnect the cables.
2. Note which slots in the housing are used for the boards. Then, slide the boards all the way out the left side of the housing.
3. Remove the Alarm Silence button, the power button pad, and the power button.
4. Disconnect the ribbon cable from the Trend Download board and the System board.
5. Gently separate the System board and Display board at the board-to-board connector.
6. Push (do NOT pull) the battery straight out the left side of the housing. Be sure not to damage the battery cover.
7. Using a 3/8 inch nut driver, remove the nut and washer that secure the power assembly jack. Remove the power shield and all line power hardware.
8. Press down on the handle so that it extends out the left side of the housing. Gently lift the tabs away from the housing to release the handle.

Monitor assembly

Refer to the assembly drawing as you assemble the monitor. See *TruSat assembly drawing* later in this manual.

Housing assembly

1. Position the right end of the handle in the slots in the right side of the housing. Press down on the handle until the left end extends beyond the left side of the housing. Gently bend the tabs as needed to position them in their slots on the left side of the housing. Slide the left end of the handle into the housing.
2. Inside the housing, position the line power jack in the housing. Outside the housing, place the power shield over the hole, then install the washer and nut over the power jack post. Install the power jack nut, using a 3/8 inch nut driver.
3. At the left side of the housing, position the battery in its slot with the side containing the cable facing toward the center of the housing. Slide the battery into the housing, taking care not to tear or slit the battery wrap.
4. Connect the System board to the Display board at the board-to-board connector.
5. Position the Trend Download board beside the System board and connect the ribbon cable to both boards.
6. Inside the housing, position the small power button in the power button hole.
7. Position the boards in their slots in the left side of the housing. Slowly slide the boards (as a unit) into the housing until you can easily connect the battery cable and the line power cable to the System board. Connect the cables.
8. Install the Alarm Silence button inside the housing. Position it so that the alarm LED is not covered.

9. Install the power button pad at S1 on the Display board by inserting the two guide "posts" through the matching holes on the Display board.
10. Slide the boards all the way into the housing, taking care not to dislodge the Alarm Silence button, the power button, and the power button pad.

Left side assembly

1. Position the SpO_2 code ring inside the left bumper and cover it with the left inner end plate.
2. Position the bumper and end plate over the left side of the housing, fitting it over the SpO_2 connector and RS-232 connector, as applicable.
3. Place the outer end plate over the bumper and install the 3 screws that secure the left bumper assembly to the housing.

Right side assembly

1. Position the speaker over the two posts inside the right bumper with the speaker cable near the center of the bumper.
2. Slip the spacer over the ComWheel encoder post and insert the encoder post through the hole in the right inner end plate. Be sure the end plate standoffs and the encoder post face away from the housing.
3. Orient the encoder with its cable toward the center of the end plate and install the washer and nut that secure the encoder to the end plate. Install the ComWheel encoder nut, using a 7/16 inch nut driver.
4. Position the right inner end plate in the right bumper, routing the speaker cable through the large hole in the inner end plate. On the outside of the bumper, align the ComWheel over the flat side of the encoder post, then press gently until the ComWheel slides into place.
5. Connect the speaker cable and the ComWheel encoder cable to the System board. Position the cables inside the housing to ensure they will not be pinched.
6. Place the right bumper over the housing. Place the outer end plate over the bumper and install the 3 screws that secure the bumper assembly to the housing.

Important: Test the monitor. See *Functional check* earlier in this chapter.

5. SERVICE PARTS

This chapter contains:

- A list of miscellaneous parts.
- A list of the TruSat parts and service kits associated with the assembly drawing of the TruSat.

NOTE: Illustrations and connector details for the System board, the Display board, and the Trend Download board (RS-232) are located in the *Troubleshooting* chapter.

5.1 Miscellaneous parts

TruSat PCA Drawings Service Kit 6050-0007-194

Includes drawings, schematics, and component lists for the System board, Trend Download board, and the Display board.

Cable, TruSat/PC RS-232 6050-0006-924

Cable, TruSat/serial printer 6050-0006-925

Fuse, T0.1A/125V, 2.5 x 6 mm (on Trend Download board) 6012-0000-100

Pole mount 6050-0007-197

Power supply, TruSat (AC to DC converter) 6050-0006-579

Power supply (optional) for use with auxiliary 12 VDC power source, such as a vehicle cigarette lighter 6021-0000-042

Printer assembly

- US 6050-0007-165
- Europe 6050-0007-167
- Japan 6050-0007-166

NOTE: Each printer assembly includes:

- Serial printer and instructions
- Cable, TruSat/serial printer
- Printer battery pack
- Printer paper, 1 roll
- Printer power supply (US, Europe, or Japan)

Printer battery pack 6002-0000-203

Printer paper, 5 rolls 6002-0000-200

Printer power supply

- US 6002-0000-199
- Europe 6002-0000-201
- Japan 6002-0000-202

Software upgrade kit, TruSat 6050-0007-182

Trend Download option, upgrade kit 6050-0007-164

Includes Trend Download software CD, TruSat/PC RS-232 cable, Trend Download board, ribbon cable, and left bumper for RS-232 connector.

Trend Download software CD 6050-0006-586

5.2 TruSat assembly

TruSat parts and service kits

The item number identifies the part shown in the assembly drawing.

Item	Description	REF
1	Plate, end, outer	6050-0006-566
	Plate, end, outer, white	6050-0006-584
2	Bumper, left (not shown)	6050-0006-569
	Bumper, left for RS-232 connector	6050-0006-915
3	Plate, end, inner left	6050-0006-568
4	Battery pack	6050-0006-578
5	Service kit, Trend Download board (RS-232)	6050-0007-160
6	Service kit, System board PCA	6050-0007-161
7	Service kit, Display board PCA	6050-0007-159
8	Handle	6050-0006-571
9	Service kit, lens	6050-0007-163
10	Button, power	6050-0006-573
11	Button, power, pad	6050-0006-953
12	Code ring, SpO_2 IMC	6050-0006-597
13	Screw, 6-32 X.5 in. PPH SS INT SEM	6019-0000-125
14	ComWheel	898794
15	Bumper, right	6050-0006-570
16	Nut, encoder, TruSat	6050-0006-582
17	Plate, end, inner right	6050-0006-567
18	Spacer	6029-0000-125
19	Button, Alarm Silence	6050-0006-574
20	Service kit, speaker	6050-0007-063
21	Shield, power	6050-0006-598
22	Power jack assembly	6050-0006-580
23	Service kit, housing, yellow	6050-0007-158
	Service kit, housing, white	6050-0007-157
24	Encoder, rotary, 16 POS w/SW, 3.3 V and washer NOTE: Includes nut that should be discarded; use only the TruSat encoder nut (item 16).	6023-0000-033

TruSat assembly drawing